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TIGHT RIBBON ARM PROTECTION (TRAP) FOR AIRCREWMAN EJECTION

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When an aircrewman ejects at high speed from a damaged aircraft the windblast (high Q force) can cause arm fractures and dislocations. These injuries may be so severe that he is unable to help himself survive after the parachute descent. The TRAP (TIGHT RIBBON ARM PROTECTION) was designed to provide ejection seat arm restraint; it consists of two nylon ribbons sewn onto either side of the crewman's parachute harness (either seat-mounted or torso harness mounted).

Each of these pulls down off the crewman's shoulder and automatically tightens over his arm as the ejection seat moves up into the air stream.

The crewman hooks up the TRAP to snubber lines as he connects into the aircraft restraint. Initial tests indicate that the TRAP system may be able to solve the arm restraint problem.

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BACKGROUND

Limb flail injury is one of the most common major injuries resulting from high speed ejection. The wind blast that strikes the aircrewman can twist and bend his arms and legs causing fractures and dislocations which prevent him from performing vital survival functions after he descends to the ground or into the sea (ref. 1).

Although many current (1984) U.S. Navy Ejection seats are equipped with a leg restraint system, none is equipped with arm restraint.

During the past decade many attempts have been made to develop a passive arm restraint, one that automatically works during ejection and requires no hookups by the aircrewman (ref. 2). These systems have shown some degree of success, but all require some modification to the ejection seat.

The purpose of this development was to determine if it is possible to design an arm restraint that is harness mounted, requiring little or no modification to the seat.

To simplify the design, the same type snubber line arrangement used for the leg restraint would also be used to pull in the arms. This was to be an active system requiring the aircrewman to hook up. After the initial hookup, the system entraps the arms automatically as the ejection seat begins to move.

The acronym for this system is 'TRAP,' which stands for 'Tight Ribbon Arm Restraint.'

DESIGN APPROACH

The most effective way to limit arm motion is to restrain both major bone linkages—the humerus and the radius. After trying several different ways to accomplish this it became evident that the simplest way was to stitch nylon ribbon to either side of the MA-2 Torso Harness (figs. 1 through 6). Each ribbon was stitched at two locations and reeved through two steel slip rings. One of these rings was sewn to the shoulder strap while the other, which was Velcroed on top of the first, was left free to slide along the loop once it pulled free of its Velcro tab. The ribbons then pull free of the shoulder epaulets, tighten on the upper arms and trap the forearms against the crewman's legs (figs. 7 through 14). Later, during seat/man separation, the snubber lines must be released when the Emergency Harness release Handle is pulled.

Because this system is harness mounted it can be configured to either a torso harness or seat-mounted harness. The ejection seat must be slightly modified by the addition of snubber blocks (similar to the leg restraint snubber blocks) to the front edge of the seat bucket, and snubber line cutters. The system is designed for center-pull ejection actuation. For best entrapment, the hands should be on the firing handle or on top of the thighs. But the system will entrap the arms when they are on the flight controls.

DEPLOYMENT TESTS AND RESULTS

Two series of tests were conducted with the TRAP restraint to observe its deployment: (1) Static Pull Tests, (2) Ejection Tower Tests. All tests were done using a GRU-7 (Martin-Baker) ejection seat which was modified with two additional snubber blocks (similar to the leg line snubber blocks) located on the lower forward edge of the seat.

Figure 1. Crewman Ready to Enter Aircraft; Front View

Figure 2. Back View of TRAP Ribbons Sewn Onto MA-2 Harness

Figure 3. Side View of TRAP System Sewn Onto MA 2 Harness

Figure 4. Crewman Seated Before Hooking Up Snubber Lines to Sliding Rings

Figure 5. Crewman Hooking Up Snubber Line to Sliding Ring

Figure 6. Crewman Looking Aft with TRAP Snubber Lines Connected

Figure 7. TRAP Ribbons Deployed Over Arms; Front View

Figure 8. TRAP Ribbon Deployed Over Arm; Side View

Figure 9. Side View of TRAP Ribbon Deployed Over Left Arm

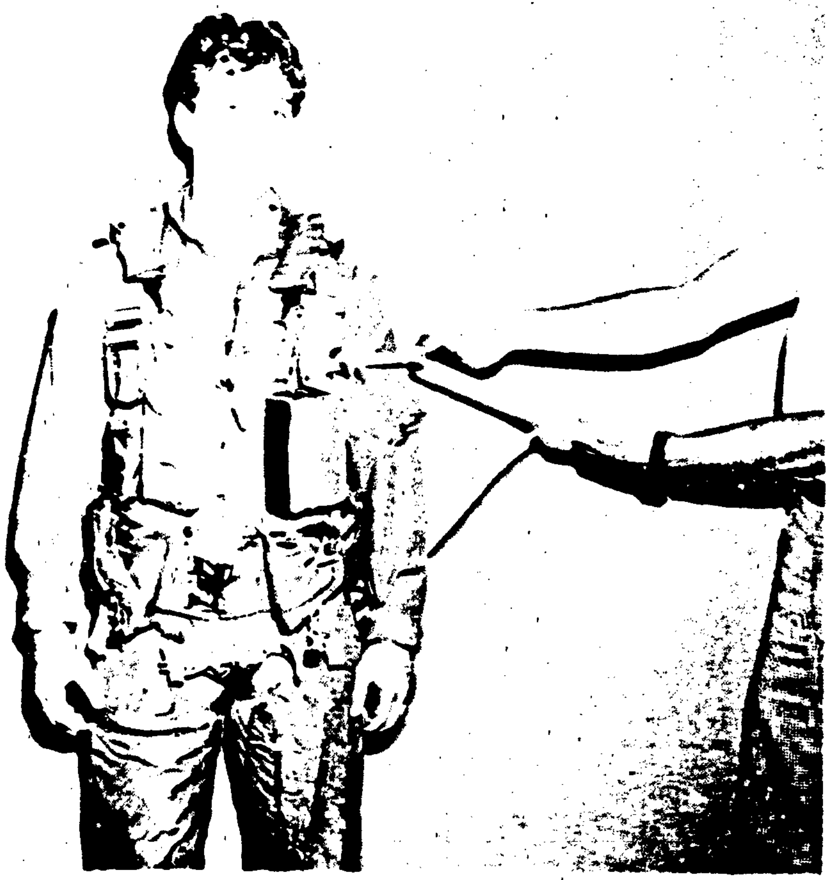

Figure 10. Routing of TRAP Ribbon; Pointing Out Free Sliding Ring

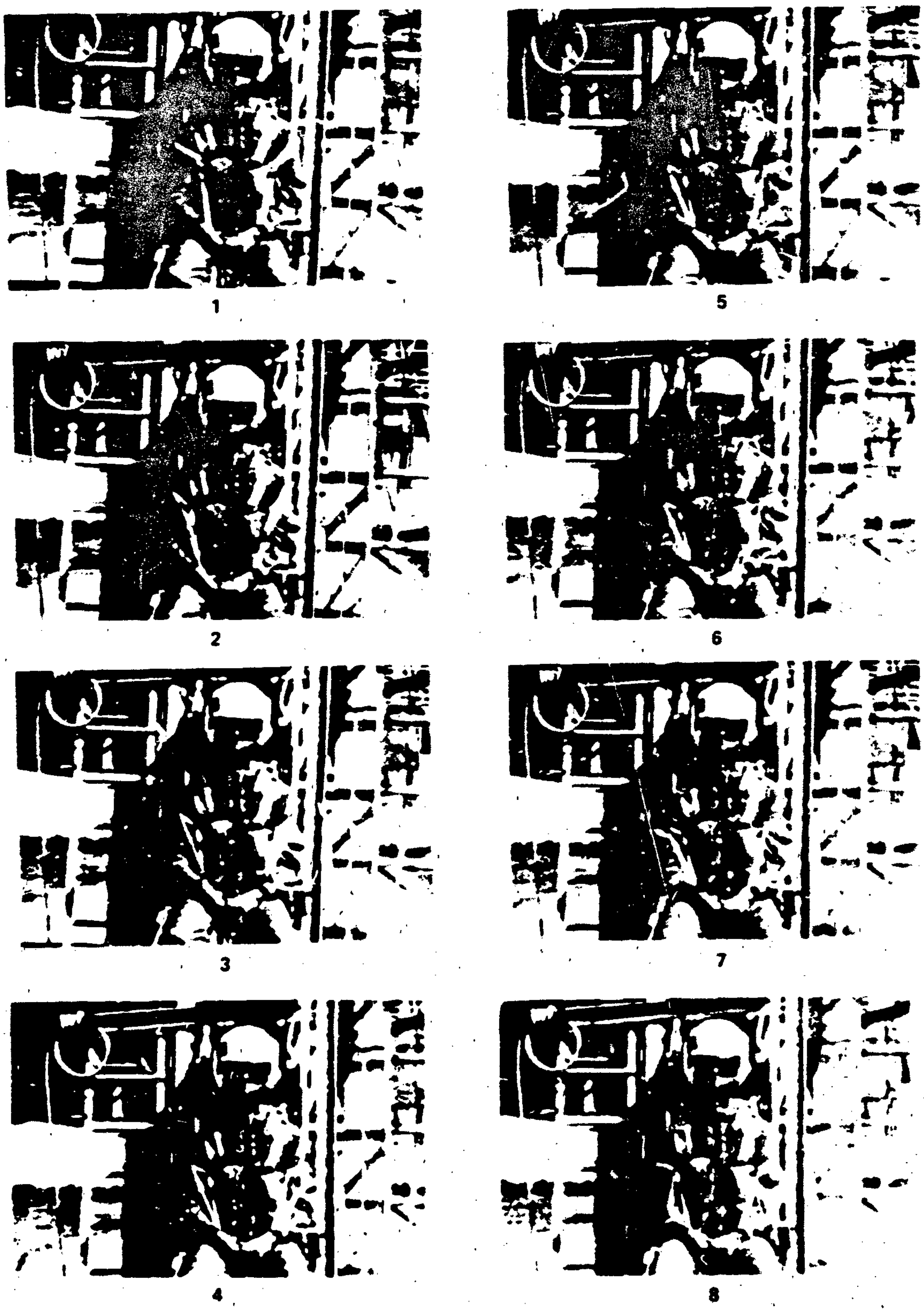

Figure 11. Sequency Showing TRAP Lanyards Pulled Manually From Below Seat

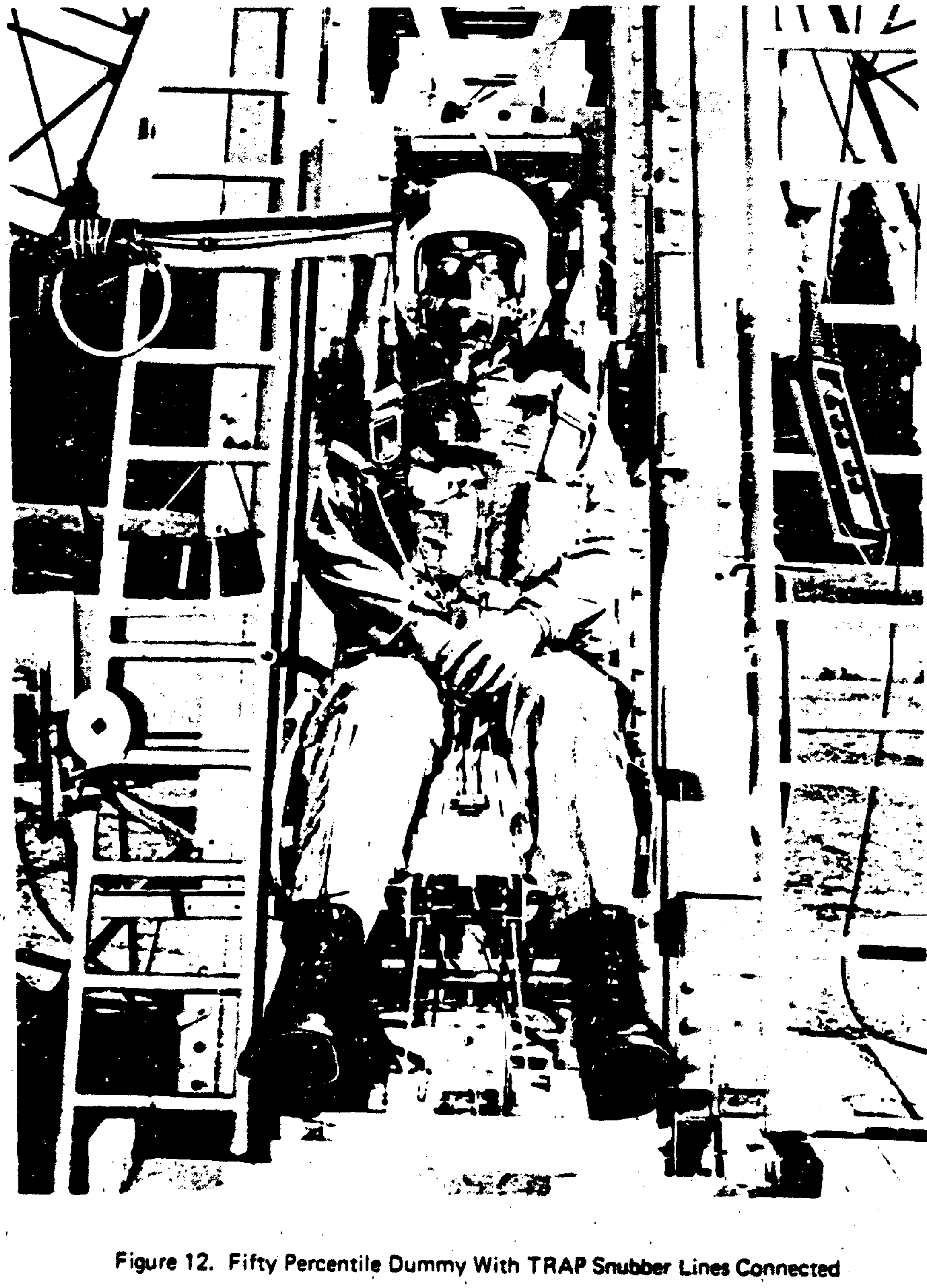

Figure 12. Fifty Percentile Dummy With TRAP Snubber Lines Connected

Figure 13. TRAP Deployed After Ejection Test #3 (Front View)

Figure 14. TRAP Deployed After Ejection Test =3 (Side View)

The Static Pull Tests were conducted using a fifty percentile subject (seated height) with the seat fixed on the NADC Ejection Tower (fig. 11). The TRAP snubber lines were pulled manually by an assistant. The test subject placed his hands in several positions while the TRAP was deployed. About ten tests were conducted, all of which demonstrated that the TRAP ribbons deployed over the crewman's arms and securely restrained them.

Three Dummy Ejection Tests (fifty percentile dummy) were conducted to determine if TRAP would work under ejection acceleration (figs. 12 through 14). For the first test the snubber lines were attached to the 'floor' with 100 pound break-away cord. High-speed movies showed that there was too much friction between the snubber lines and the snubber blocks; the right side of the TRAP deployed over the arm (but not tightly), and the left side never deployed.

For the second ejection a 200 pound break-away cord was used. Both sides successfully deployed but were not very tight over the arms.

For the third ejection a 400 pound break-away cord was used. Again, both sides successfully deployed over the dummy's arms but with little tension; the break-away cords were still too low in strength.

No further tests were conducted since these tests demonstrated that the TRAP system can deploy during ejection acceleration and with the proper break-away cord, effectively restrain the arm.

CONCLUSIONS

1. The TRAP system appears to be a simple and effective way to protect an aircrewman's arms from the damaging effects of high Q windblast; it can be designed to immobilize both the upper and lower arm until seat/man separation takes place.

2. Although flight testing has not been conducted, it appears that the TRAP system could be used in the aircraft with no degradation of aircrew performance.

3. At least a 600- to 800-pound shear rivet should be used on each floor attachment to ensure adequate tensioning of the TRAP snubber lines.

RECOMMENDATIONS

1. The TRAP system should be refined for operational use, then tested as follows:

   a. Ejection tower tests at NADC with dummies and live subjects to determine the best value breaking strength for the snubber line shear pins.

   b. High Q Windblast dummy tests at Dayton T. Brown Company.

   c. Technical Evaluation at the Naval Air Test Center for aircrewman acceptance of ingress or egress from the cockpit.

   d. Seat/man separation tests at NADC with dummies to assure that there are no hang-ups.

   e. Evaluation by at least two Fighter/Attack Squadrons for aircrewman acceptance.

   f. High-Speed Ejection test at the Naval Weapon Center to verify that the complete system will function under actual high-speed ejection conditions.

2. The TRAP system should be tested together with the 'Y' strap (ref. 3) which is used for improving negative Gz restraint. Both of these 'fixes' to the MA-2 harness should be evaluated together to assure compatibility.

ACKNOWLEDGMENTS

Special thanks are due to Rod Pursell, a qualified technician, for his support in the fabrication of the TRAP system onto the MA-2 Torso Harness.

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